A Proposal for the Enhancement of Autonomous Marine Vehicle Testing in South Florida Testing Facility Range

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LONG-TERM GOAL

The long-term goal of this proposal is to further improve the Navy ocean technology and scientific capabilities, as well as provide the scientific community with a natural ocean laboratory in the existing SFTF range operated by NSWC-CD.

OBJECTIVE

The proposal objective is to evaluate the performance of marine vehicles by carrying out six scientific experiments at NSWC-CD's South Florida Testing Facility (SFTF) Range. These experiments are: 1) to characterize the remote sampling performance of AUVs and sensor systems for coastal mine reconnaissance and surveillance tasks, and to evaluate the impact of the environment on navigation, communications, and object detection/classification sensors; 2) to evaluate the reliability of deploying and operating AUVs in stormy weather and high sea states including the quantification of the effects on AUV navigation, communication and control performances; 3) to investigate the performance of AUV-based sensor systems combined with surface radar systems for mapping the sub-surface sub-meso-scale dynamics associated with small-scale eddies and internal waves on the shelf circulation influenced by tides, low-frequency flows, current, and surface winds, and their net impact of these processes on AUV performance and acoustic propagation (FAU & U Miami); 4) to provide a detailed description of the physical-oceanographic variability that takes place within the SFTF range on time scales from hourly to seasonal, and to identify the processes that causes this varability (U South Florida); 5) to quantify range-dependent variations in bathymetry and inhomogenous bottom properties and varability in the sound speed profiles induced by internal waves on long-range transmission of sound in the littoral ocean (U Miami); 6) to conduct a baseline survey of the biological, ecological and geological environmental conditions of the SFTF to optimize sampling by the AUV and other sensors, coupled with preliminary evaluation of direct AUV biological assessment (NOVA Southeastern U).

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Among these experiments, (1), (2) and (5) were funded through separate proposals, and thus their approaches and working progress will not be described in this report.

APPROACH

The central theme of the oceanographic experiments is to understand and calibrate the underwater environment with respect to the physics, acoustics, geology, and biology of the range. To achieve the scientific goals of these experiments the existing infrastructure at the range must be enhanced and this will be approached with the specific objective of providing a calibrated site for oceanographic and engineering studies using marine vehicles in the future. A central theme in the engineering studies is to develop a permanent AUV underwater node facility that is hard wired to shore so that extended experimentation including multiple AUV sampling schemes can be supported.

With regard to the 4D current experiment, the RSMAS OSCR radar system will be deployed in early 1999 at the SFOMC site. This system measures the surface current field over a 5km X 11km grid with 250m grid cell spacing. Concurrently, sub-surface current and density fields will be measured over a 30-day period using multiple ADCP and CTD probes on the FAU AUV, and a sub-surface Cyclesonde mooring. The AUV will provide horizontal and vertical flow measurements around a mooring at the highest spatial resolution, and hence the smallest scales over a 2km X 2km grid embedded within a 4km x 4km grid for the shipboard measurements [1].

In terms of the biogeological surveys, Nova Southeastern University Oceanographic Center (NSUOC) will develop a shallow water range bio-diversity inventory, plan and monitor the environmental assets within the range. Biology and geology will be mapped onto a detailed bathymetry basemap of the range to be provided by the US Henson, and the mapping information will be enhanced using comlementary techniques such as air photographs, bottom trawling, grab sampling and core drilling and and underwater photography and video.

As part of these studies extensive oceanographic environmental monitoring arrays will be installed enabling long term observations to be made that will support the described and future experiments. The NSUOC and USF will deploy a 3D mooring array in conjunction with the Cyclesonde, OSCR and a combination of recording temperature and salinity sensors on each mooring. This data will provide important insights into the interaction between the Gulf Stream and near shelf circulation and their spatial-temporal variability.

WORK COMPLETED

Due to the delayed funding, the project was started approximately by the end of July of 1998. Since then, a monthly meeting was held at NSUOC, during which the South Florida Ocean Measurement Center (SFOMC) partners orchestrate planning efforts and develop milestones for the six experiments. Thus far, the power and electronics design by FAU for the shallow water node is complete. This node can support up to 10 independent instruments at nearby sites, including AUV multiple AUV docking stations. The node is equipped with circuitry for ground fault interruption, over current/voltage protection, and intelligent power management capability. These instrument interfaces are highly modular, thus allowing the instruments's end to be reconfigured and/or replaced cost-effectively. Each of these generic interfaces supplies 52Vdc power to its connected instrument, and supports all RS422, 10/100BT Ethernet and LonTalk data communication. To support power and data relay from shore, a two mile long electro-optic cable, which consists of 6 single-mode fibers and 6 14AWG copper power

conductors, has been purchased. In addition, cables and connectors to be mated with individual instruments have also been finalized. Table 1 provides all the instruments (with their latitude / longitude co-ordinates) that will be connected to the node during the experiments, and Figure 1 shows graphically the relative positions of these instruments. Figure 2 describes the overall functional block diagram of the node in terms of power and data capabilities.

The US Henson was deployed along the coast of South Florida in the early spring of 1998, and this survey has provided a preliminary but valuable set of bathymetry data for all the planned experiments. It is anticipated that the next bathymetry survey will be carried out at the end of 1998.

With regard to the biogeological surveys, NSUOC has made progress on fish and coral surveys, and have obtained low level detailed aerial photography. This information will be mapped onto the bathymetry data as it becomes available, providing a first step towards producing an accurate environmental basemap.

Although the 4D current experiment is to be carried out in early 1999, a preliminary analysis of AUV-based bathymetry, CTD and current profile data that were collected in the vicinity of the SFTF range is complete. These data were compared to those obtained from a local moored ADCP and wave buoys. During the mission this area was influenced by the passage of a weak cold front there winds approached 10m/s. The moored ADCP indicated wave activity with periods of about 4hr and barotropic tidal currents were aligned in the along-shelf direction with amplitudes of about 5-7cm/s. The AUV derived current field also revealed wave-like activity, and the Doppler Velocity Log provided a high-resolution bottom terrain profile between the two along-shore reef tracks [1,2].

The USF/NSUOC experiment has been implemented into the SFOMC range plan. Some changes were made to adjust the array and schedule to the modified plans of the SFOMC partners. Thus far, the deployment scheme for the NE, NW, SE and SW mooring arrays and their designs is complete. They have also started developing plans for the data acquisition and archiving, and the arrays will be built and tested by the end of 1998.

Instrument	Dist. from MUX (m)	GPS
MUX	0	26° 3.796”N 80° 5.498”W.
Environmental Array	550	26° 3.788”N 80° 4.191”W.
Peacock	100	26° 3.759”N 80° 5.539”W.
5-Head ADCP	200	26° 3.722”N 80° 5.581”W.
Cyclesonde	10	26° 3.796”N 80° 5.492”W.
Modem Source	250	26° 3.920”N 80° 5.497”W.
Modem Receiver	50	26° 3.796”N 80° 5.470”W.
AUV Docks	70	26° 3.821”N 80° 5.525”W.

Table 1: The node instruments’ and their coordinates.

IMPACT/APPLICATION

This project is expected to stimulate the development of many related key technologies such as sampling methodologies, sensor and navigation performance, and operational envelopes such as range,

sea-state, and mission duration. Of critical impact to the US Navy is the enhancement of littoral warfighting capability, and clandestine and rapid environmental assessment and mine reconnaissance are two very significant parts of that capability.

TRANSITIONS

This work will transition into Ocean Sampling Systems using low cost AUVs, and VSW mine counter-measure operations.

RELATED PROJECTS

1 – Remote Sampling and Survey of Shallow Water Using AUVs with Application to Mine Reconnaissance (ONR).

2 – Sampling and Survey with AUVs in Adverse Weather Conditions (ONR).

3 – AUV Navigation and Platform Development (ONR).

4 – Operations Support for Experiments Usng FAU AUVs (ONR).

REFERENCES / PUBLICATIONS

[1] **Sub-mesoscale Coastal Ocean Dynamics Using Autonomous Underwater Vehicles and HF Radar**, S.M. Smith, P.E. An, J. Park, L.K. Shay, H.Peters, J. VanLeer, 2nd conference on Coastal Atmospheric and Oceanic Prediction, Phoenix, AZ, American Meteorological Society, pp.143-150.

[2] **Coastal Oceanography Using A Small AUV**, P.E. An, M. Dhanak, L.K. Shay, J.VanLeer, (*submitted to*) J. Atmos. Oceanogr. Tech.

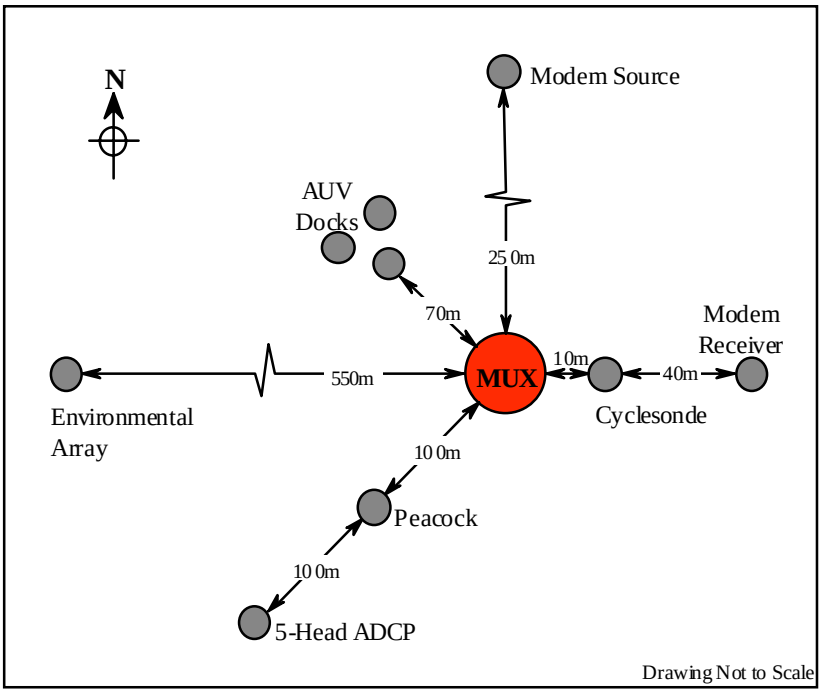

Figure 1: A graphical representation of the SFOMC shallow water node's instruments

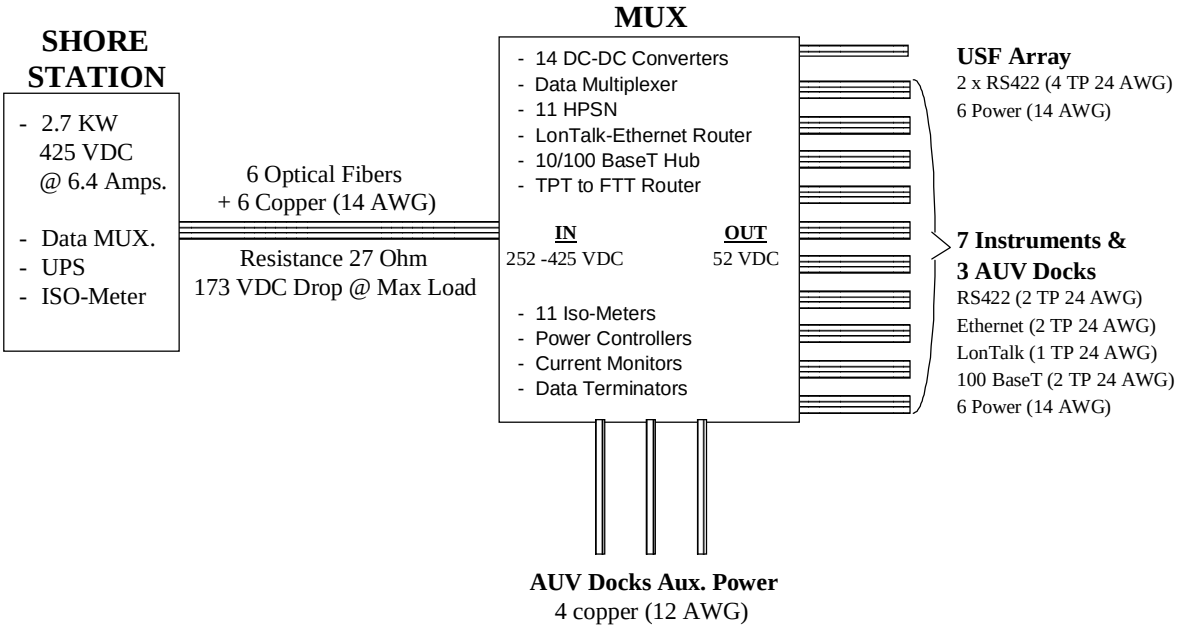

Figure 2: A functional block diagram of the SFOMC shallow water node.